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## *In-Theater Hospitalizations of US and Allied Personnel during the 1991 Gulf War*

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## In-Theater Hospitalizations of US and Allied Personnel during the 1991 Gulf War

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The postwar morbidity of Gulf War veterans has been closely examined. However, data have not been available to evaluate morbidity suffered during the 1991 Gulf War. In this report, the authors examine archived records of hospitalizations in US military facilities in the Kuwaiti theater of operations or those medically evacuated to facilities in Europe. Using multivariable logistic regression modeling, the authors determined that service personnel at greatest odds for “in-theater” hospitalization were enlisted, female, White, Reservist, Army, and health care workers. No increase in odds was observed for oil well fire smoke exposure or possible exposure to the nerve agent hazard areas. Although these data may be incomplete, they represent the best-known data reflecting in-theater hospitalizations during the Gulf War of 1991 and show remarkable similarities in risk factors to those for postwar hospitalization.

environmental exposure; hospitalization; military medicine; morbidity; occupational exposure; Persian Gulf syndrome; veterans

Abbreviations: CI, confidence interval; DoD, Department of Defense; ICD-9-CM, *International Classification of Diseases*, Ninth Revision, Clinical Modification; OR, odds ratio.

The 1991 Gulf War was one of the shortest full-scale conflicts in US history. Beginning in August 1990, almost 697,000 US military personnel were deployed to the region in support of what became 40 days of aerial assault followed by 5 days of ground combat (1). The relative ease with which the US-led coalition swept through Kuwait and southern Iraq was unanticipated by even the most optimistic military planners. Prior to the beginning of the war, military analysts suggested that there might be heavy casualties when the US-led coalition confronted a large, well-equipped, and entrenched Iraqi Army (2). Although ground battles were described as fierce at times during the 5 days of ground fighting, battle- and non-battle-related morbidity and mortality rates were lower than in any other major US war (3). Additionally, there was widespread concern by coalition forces regarding the possible use of chemical and biological weapons as a last-ditch effort by some Iraqi commanders (4, 5). However, those weapons were not known to have been

used against coalition forces, and a cease-fire was declared on February 28, 1991 (1, 4).

Despite in-theater successes, reports of postwar illness among veterans have resulted in much research into the postwar health of Gulf War veterans in the last decade since the war. There have been numerous studies demonstrating that Gulf War veterans are more likely to self-report symptoms (6–11) and adverse pregnancy outcomes (12) than their military peers. However, large epidemiologic studies have found no definitive evidence to suggest excess morbidity among Gulf War veterans as measured by hospitalizations (13–15), mortality due to diseases (16–19), or birth defects among livebirths in active-duty members within 2 years of the Gulf War (20). Additionally, epidemiologic studies focusing on the health impacts of specific wartime exposures compared Gulf War veterans and found no excess in hospitalizations for those personnel possibly exposed to the smoke from Kuwaiti oil well fires (21) or those personnel possibly

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exposed to nerve agents released as a result of the US demolition of a munitions depot at Khamisiyah, Iraq (22, 23). However, because electronic data were unavailable, to date there have been no large investigations of morbidity during the war. This retrospective report is the first to summarize the epidemiologic findings obtained from examining more than 28,000 paper records of US and coalition in-theater hospitalizations that were medically evacuated to medical treatment facilities during the Gulf War.

## MATERIALS AND METHODS

### Study population

US military personnel who were on active duty, Reserve, or National Guard status and deployed to the Gulf War region for 1 or more days during the period, August 1, 1990, through July 31, 1991, were the focus of this investigation. Demographic and deployment data were available for US personnel only and were provided by the Defense Manpower Data Center, Monterey Bay, California. Gulf War veteran demographic data included date of birth (used to compute age), sex, marital status, race/ethnicity, home state, military service branch, military component (active duty, Reserve, National Guard), Department of Defense (DoD) primary military occupational specialty (10 major groups defined by the *DoD Occupational Conversion Manual*) (24), military rank, date of separation from military service, and dates in and out of theater. Additionally, as in previous reports (13, 21, 25), a prewar hospitalization covariate was created to denote an individual's hospitalization in any DoD military treatment facility for any cause during the 12-month period prior to August 1, 1990.

### Gulf War exposure data

Environmental exposures, such as Kuwaiti oil well fire smoke (21), depleted uranium (26, 27), dust (28), and possible exposure to nerve agents after the US-led demolition of a large munitions depot at Khamisiyah, Iraq (29, 30), have been suggested as possible factors affecting the postwar health of veterans. As part of our investigation of in-theater hospitalizations, estimates of possible exposure to the Kuwaiti oil well fire smoke and the 2002 plume modeling of the destruction of the Khamisiyah munitions depot are included in this report (21–23). Although these data are described in detail elsewhere (21–23), a brief description is provided.

The Iraqi Army ignited over 600 oil wells during their withdrawal from Kuwait in 1991 (21, 31). The resulting massive clouds of smoke raised concerns that US troops possibly exposed to these pollutants might experience adverse health effects. In response, the US Army Center for Health Promotion and Preventive Medicine in collaboration with the National Oceanic and Atmospheric Administration/Air Resources Laboratory estimated 24-hour unit exposure data. These data were overlaid onto troop location data using a geographic information system to produce troop unit exposure estimates throughout the period that the fires burned (21).

In June 1996, the DoD announced that the United Nations strongly suspected that rockets equipped to carry chemical

weapons had been destroyed in March 1991 by US forces near Khamisiyah, Iraq (30). This prompted meteorologic and dispersion modeling of the possible release of sarin and cyclosarin to model estimated hazard areas. These data were overlaid onto troop location data to identify those personnel possibly exposed to nerve agents from the destruction of Khamisiyah in March 1991. The final report, released in April 2002, identified 101,752 Gulf War veterans as having been possibly exposed in the hazard areas created by the destruction of munitions at Khamisiyah (30).

### Gulf War hospitalization data

In June 1998, the Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses began work on a records database of all Gulf War inpatient hospital treatment records archived at the National Personnel Records Center in St. Louis, Missouri (32). These archived records were thought to represent approximately 75 percent of the total reported admissions at 44 Army hospitals, 15 Air Force hospitals, and five or more Navy hospitals in the Kuwaiti theater of operations (32). Therefore, additional efforts were made to investigate for inpatient records of Gulf War evacuees to military hospitals in Europe who might not have corresponding in-theater admission records (32). This work concluded in October 1999 with the identification of 22,444 admissions occurring in the Kuwaiti theater of operations and 5,563 evacuated admissions to hospitals in Europe.

In November 2000, at the direction of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, a team of deployment health specialists and medical record abstractors began reviewing all archived Gulf War inpatient treatment records to determine if the existing archived inpatient paper records contained sufficient information to conduct research on the inpatient hospitalization experience of Gulf War veterans (32). This work resulted in the construction of a database that could be used to investigate in-theater hospitalizations during the 1991 Gulf War. Abstracted hospitalization data were reviewed twice in their entirety and run through a series of quality assurance steps to achieve the greatest possible accuracy. These data included Social Security number, admission date, patient identification, record identification, and associated medical discharge diagnoses coded according to the *International Classification of Diseases*, Ninth Revision, Clinical Modification (ICD-9-CM) (33). Additionally, these data contained demographic and other descriptive data, including race, sex, date of birth, service branch, marital status, military component, military rank, DoD primary military occupational specialty, and country code, which identified the nationality of all patients. For the purposes of this report, in-theater hospitalizations will be used to encompass those hospitalized within the Kuwaiti theater of operations and those medically evacuated to DoD treatment facilities in Europe.

### Study outcomes

Investigation of outcomes included in-theater hospitalization for any cause, frequency of in-theater hospitalization with a diagnosis in any of 15 broad ICD-9-CM diagnostic

**TABLE 1. Characteristics of Gulf War veterans with in-theater hospitalization records, August 1, 1990, to July 31, 1991**

Variable	Gulf War deployed ( <i>n</i> = 683,479)		Gulf War hospitalized ( <i>n</i> = 18,631)		<i>p</i> value*
	No.	%	No.	%	
Oil well fire†					
Not under plume	255,653	37.4	6,907	37.1	0.2773
Under plume	427,826	62.6	11,724	62.9	
Khamisiyah hazard area†					
Not in hazard area	584,208	85.5	15,092	81.0	<0.0001
In the hazard area	99,271	14.5	3,539	19.0	
Gender					
Male	634,504	92.8	16,332	87.7	<0.0001
Female	48,975	7.2	2,299	12.3	
Age (years)					
17–22	222,835	32.6	5,389	28.9	<0.0001
23–26	162,802	23.8	4,484	24.1	
27–32	150,375	22.0	4,103	22.0	
33–65	147,467	21.6	4,655	25.0	
Prewar hospitalization					
No	641,255	93.8	16,453	88.3	<0.0001
Yes	42,224	6.2	2,178	11.7	
Marital status					
Single	328,643	48.1	7,272	39.0	<0.0001
Married	354,836	51.9	11,359	61.0	
Military pay grade					
Commissioned officer	66,092	9.7	1,196	6.4	<0.0001
Warrant officer	8,954	1.3	261	1.4	
Enlisted	608,433	89.0	17,174	92.2	
Race/ethnicity					
White	460,295	67.4	13,040	70.0	<0.0001
Black	156,953	23.0	4,755	25.5	
Other	66,231	9.7	836	4.5	

Table continues

categories, the 10 most common in-theater three-digit diagnoses, the overall five most common in-theater three-digit diagnoses for each ICD-9-CM diagnostic category, and the five most common in-theater three-digit diagnoses by broad occupational category. Additionally, the top 10 three-digit hospital diagnoses among other coalition forces were investigated. Hospital admissions were scanned in chronologic order for the diagnostic code of interest. Frequency and regression analyses were based on unique personnel having at least one diagnosis captured from the hard-copy medical records.

### Statistical analyses

Following descriptive investigation of the population characteristics of those hospitalized and not hospitalized in theater, univariate analyses were performed to assess the significance of associations between demographic, expo-

sure, and deployment variables and hospitalization. A multivariable model was developed to further assess significant associations, collinearity, and confounding, while simultaneously adjusting for all other variables in the model. Using multivariable logistic regression, we further investigated the in-theater hospitalization experience of Gulf War veterans during the period from August 1, 1990, to July 31, 1991. A manual backward stepwise elimination model approach was used on the saturated logistic regression model to arrive at a reduced model by removing those variables that were insignificant at the  $\alpha = 0.05$  level and not confounding the other measures of association. The final model included only those variables independently associated with the outcome of interest with  $p < 0.05$ . Statistical modeling, producing adjusted odds ratios and associated 95 percent confidence intervals, was performed using SAS version 8.0 software (SAS Institute, Inc., Cary, North Carolina).

TABLE 1. Continued

Variable	Gulf War deployed (n = 683,479)		Gulf War hospitalized (n = 18,631)		p value*
	No.	%	No.	%	
Service component					
Active duty	581,433	85.1	14,676	78.8	
Reservists	102,046	14.9	3,955	21.2	<0.0001
Branch of service					
Navy and Coast Guard	156,160	22.9	1,362	7.3	
Army	342,752	50.2	12,685	68.1	
Marines	102,633	15.0	2,197	11.8	
Air Force	81,934	12.0	2,387	12.8	<0.0001
Time period in theater					
August–October, 1990					
Not in theater	357,694	52.3	7,693	41.3	
In theater	325,785	47.7	10,938	58.7	<0.0001
November 1990–January 1991					
Not in theater	165,819	24.3	2,851	15.3	
In theater	517,660	75.7	15,780	84.7	<0.0001
February–April, 1991					
Not in theater	90,491	13.2	2,501	13.4	
In theater	592,988	86.8	16,130	86.6	0.5120
May–July, 1991					
Not in theater	416,971	61.0	12,037	64.6	
In theater	266,508	39.0	6,594	35.4	<0.0001
Occupational category					
Infantry, gun crews, seamanship specialists	168,820	24.7	3,730	20.0	
Electrical repair	52,258	7.7	822	4.4	
Communications/intelligence	65,386	9.6	1,517	8.1	
Health-care specialists	47,694	7.0	1,894	10.2	
Other technical	14,400	2.1	471	2.5	
Functional support specialists	81,963	12.0	2,493	13.4	
Electrical/mechanic	132,447	19.4	3,290	17.7	
Crafts	25,462	3.7	732	3.9	
Service support	86,939	12.7	3,469	18.6	
Nonoccupational	8,110	1.2	213	1.1	<0.0001

\* p values based on Pearson's chi-square test of association.

† Data sources are recorded in detail in previous publications (21–23).

## RESULTS

This population of 683,479 (98.1 percent) Gulf War veterans with complete covariate data was 93 percent male, 52 percent married, 89 percent enlisted, 85 percent active duty, 50 percent Army, and 25 percent infantry, with over half less than 26 years of age. Additionally, 62.6 percent were exposed to the smoke plumes caused by the Kuwaiti oil well fires, and 14.5 percent were possibly exposed to nerve agents after the destruction of the Khamisiyah munitions depot. Of those with complete covariate data, 18,631 were hospitalized at least one time in theater during the period from August 1, 1990, to July 31, 1991. When compared with the Gulf War deployed population as a whole, proportionally

more in-theater hospitalizations than expected occurred among married individuals (61.0 percent vs. 51.9 percent), Army personnel (68.1 percent vs. 50.2 percent), those in the oldest age category (25.0 percent vs. 21.6 percent), females (12.3 percent vs. 7.2 percent), Reserve or National Guard personnel (21.2 percent vs. 14.9 percent), and those with a hospitalization record within the year prior to August 1, 1990 (11.7 percent vs. 6.2 percent). Other statistically significant univariate associations included rank, race/ethnicity, time period in theater, occupational category, and Khamisiyah hazard area exposure (table 1).

In the analysis of broad diagnostic categories, the category of injury and poisoning (ICD-9-CM codes 800–999)

**TABLE 2. Frequencies of the five most common in-theater hospitalization diagnoses for 15 ICD-9-CM\* diagnostic categories for US Gulf War veterans, August 1, 1990, to July 31, 1991**

ICD-9-CM category	Diagnoses	Frequency of diagnoses (n = 30,740) (no.)	% of category	% of total diagnoses
Infectious and parasitic diseases (codes 001–139)		1,093		3.6
079	Viral and chlamydial infection in conditions classified elsewhere	372	34.0	1.2
008	Intestinal infections, other organisms	109	10.0	0.4
052	Chickenpox	75	6.9	0.2
009	Ill-defined intestinal infections	72	6.6	0.2
078	Other diseases due to viruses and chlamydiae	72	6.6	0.2
Neoplasms (codes 140–239)		249		0.8
239	Neoplasms, unspecified nature	51	20.5	0.2
214	Lipoma	47	18.9	0.2
216	Benign neoplasm of skin	13	5.2	<0.1
218	Uterine leiomyoma	13	5.2	<0.1
228	Hemangioma and lymphangioma, any site	12	4.8	<0.1
Endocrine, nutritional, and metabolic diseases and immunity disorders (codes 240–279)		660		2.2
276	Disorders of fluid, electrolyte, and acid-base balance	418	63.3	1.4
250	Diabetes mellitus	95	14.4	0.3
242	Thyrotoxicosis with or without goiter	26	3.9	0.1
272	Disorders of lipid metabolism	26	3.9	0.1
274	Gout	26	3.9	0.1
Diseases of the blood and blood-forming organs (codes 280–289)		116		0.4
285	Other, unspecified anemias	41	35.3	0.1
289	Other diseases of blood and blood-forming organs	33	28.4	0.1
280	Iron deficiency anemias	9	7.8	<0.1
282	Hereditary hemolytic anemias	9	7.8	<0.1
288	Diseases of white blood cells	9	7.8	<0.1
Mental disorders (codes 290–319)		1,593		5.2
309	Adjustment reaction	444	27.9	1.4
300	Neurotic disorders	234	14.7	0.8
301	Personality disorders	224	14.1	0.7
311	Depressive disorder, not elsewhere classified	123	7.7	0.4
308	Acute reaction to stress	120	7.5	0.4
Diseases of the nervous system (codes 320–389)		1,358		4.4
346	Migraine	231	17.0	0.8
354	Mononeuritis of upper limb and mononeuritis multiplex	110	8.1	0.4
364	Disorders of the iris and ciliary body	84	6.2	0.3
389	Hearing loss	78	5.7	0.3
372	Disorders of conjunctiva	55	4.1	0.2
Diseases of the circulatory system (codes 390–459)		1,139		3.7
401	Essential hypertension	346	30.4	1.1
455	Hemorrhoids	159	14.0	0.5
427	Cardiac dysrhythmias	154	13.5	0.5
413	Angina pectoris	67	5.9	0.2
456	Varicose veins of other sites	44	3.9	0.1
Diseases of the respiratory system (codes 460–519)		1,879		6.1
493	Asthma	678	36.1	2.2
486	Pneumonia, organism unspecified	214	11.4	0.7
473	Chronic sinusitis	102	5.4	0.3

Table continues

TABLE 2. Continued

ICD-9-CM category	Diagnoses	Frequency of diagnoses (n = 30,740) (no.)	% of category	% of total diagnoses
461	Acute sinusitis	90	4.8	0.3
490	Bronchitis, not specified as acute or chronic	81	4.3	0.3
Diseases of the digestive system (codes 520–579)		3,864		12.6
558	Other noninfectious gastroenteritis and colitis	1,572	40.7	5.1
550	Inguinal hernia	423	10.9	1.4
520	Disorders of tooth development and eruption	237	6.1	0.8
530	Diseases of esophagus	118	3.1	0.4
540	Acute appendicitis	113	2.9	0.4
Diseases of the genitourinary system (codes 580–629)		1,874		6.1
592	Calculus of kidney and ureter	530	28.3	1.7
599	Other disorders of urethra and urinary tract	234	12.5	0.8
608	Other disorders of male genital organs	166	8.9	0.5
604	Orchitis and epididymitis	119	6.4	0.4
625	Pain and other symptoms associated with female genital organs	98	5.2	0.3
Complications of pregnancy, childbirth, and puerperium (codes 630–676)		105		0.3
640	Hemorrhage in early pregnancy	31	29.5	0.1
634	Spontaneous abortion	24	22.9	0.1
633	Ectopic pregnancy	14	13.3	0.1
643	Excessive vomiting in pregnancy	13	12.4	<0.1
632	Missed abortion	7	6.7	<0.1
Diseases of the skin (codes 680–709)		1,138		3.7
682	Other cellulitis and abscess	438	38.5	1.4
685	Pilonidal cyst	107	9.4	0.4
692	Contact dermatitis and other eczema	75	6.6	0.2
705	Disorders of sweat glands	61	5.4	0.2
706	Diseases of sebaceous glands	59	5.2	0.2
Diseases of the musculoskeletal system (codes 710–739)		3,908		12.7
724	Other and unspecified disorders of back	1,138	29.1	3.7
719	Other and unspecified disorders of joint	465	11.9	1.5
717	Internal derangement of knee	351	9.0	1.1
718	Other derangement of joint	304	7.8	1.0
729	Other disorders of soft tissues	252	6.4	0.8
Symptoms, signs, and ill-defined conditions (codes 780–799)		3,106		10.1
786	Symptoms involving respiratory system and other chest symptoms	719	23.1	2.3
780	General symptoms (e.g., sleep disturbance, drowsiness)	664	21.4	2.2
789	Other symptoms involving abdomen and pelvis	579	18.6	1.9
784	Symptoms involving head and neck	337	10.9	1.1
787	Symptoms involving digestive system	324	10.4	1.1
Injury and poisoning (codes 800–999)		8,537		27.8
959	Injury, other and unspecified	698	8.2	2.3
836	Dislocation of knee	492	5.8	1.6
844	Sprains and strains of knee and leg	428	5.0	1.4
847	Sprains and strains of other and unspecified parts of back	358	4.2	1.2
845	Sprains and strains of ankle and foot	306	3.6	1.0

\* ICD-9-CM, *International Classification of Diseases*, Ninth Revision, Clinical Modification, using three-digit codes.



**TABLE 3. Frequencies for the 10 most common in-theater hospitalization diagnoses for US Gulf War veterans, August 1, 1990, to July 31, 1991**

ICD-9-CM* category	Diagnosis	Frequency of diagnoses (n = 30,740) (no.)	% of total diagnoses
Code 558	Other noninfectious gastroenteritis and colitis	1,572	5.1
Code 724	Other and unspecified disorders of back	1,138	3.7
Code 786	Symptoms involving respiratory system and other chest symptoms	719	2.3
Code 959	Injury, other and unspecified	698	2.3
Code 493	Asthma	678	2.2
Code 780	General symptoms (e.g., sleep disturbance, drowsiness)	664	2.2
Code 789	Other symptoms involving abdomen and pelvis	579	1.9
Code 592	Calculus of kidney and ureter	530	1.7
Code 836	Dislocation of knee	492	1.6
Code 719	Other and unspecified disorders of joint	465	1.5

\* ICD-9-CM, *International Classification of Diseases*, Ninth Revision, Clinical Modification, using three-digit codes.

accounted for the largest percentage of the 30,740 unique diagnoses attributed to US personnel (27.8 percent). Other categories that accounted for large percentages of diagnoses among US personnel included disorders of the musculoskeletal system (12.7 percent), disorders of the digestive system (12.6 percent), and ill-defined conditions (10.1 percent) (table 2).

Among three-digit diagnoses in US personnel, noninfectious gastroenteritis and colitis (ICD-9-CM code 558) was the most common (5.1 percent) (table 3). Symptoms involving the respiratory system and other chest symptoms

(ICD-9-CM code 786) and the diagnosis of asthma (ICD-9-CM code 493) were in the top five most common in-theater diagnoses. These diagnoses differed somewhat from the top 10 three-digit diagnoses seen among coalition forces. The most frequent diagnosis in this non-US group was open wound of unspecified sites (ICD-9-CM code 879) (table 4). Because demographic and exposure data were unavailable for coalition troops, they were excluded from any analysis beyond these simple diagnostic counts.

Regression diagnostics for investigation of the pairwise correlations and the variance inflation factor suggested that a

**TABLE 4. Frequencies for the 10 most common in-theater hospitalization diagnoses for US allies, August 1, 1990, to July 31, 1991**

ICD-9-CM* category	Diagnosis	Frequency of diagnoses (n = 1,699) (no.)	% of total diagnoses
Code 879	Open wound of other and unspecified sites, except limbs	77	4.5
Code 959	Injury, other and unspecified	71	4.2
Code 558	Other noninfectious gastroenteritis and colitis	67	3.9
Code 873	Other open wound of head	42	2.5
Code 999	Complications of medical care, not elsewhere recorded	42	2.5
Code 789	Other symptoms involving abdomen and pelvis	38	2.2
Code 891	Open wound of knee, leg (except thigh), and ankle	37	2.2
Code 493	Asthma	26	1.5
Code 780	General symptoms (e.g., sleep disturbance, drowsiness)	26	1.5
Code 786	Symptoms involving respiratory system and other chest symptoms	23	1.4

\* ICD-9-CM, *International Classification of Diseases*, Ninth Revision, Clinical Modification, using three-digit codes.

**TABLE 5. Adjusted odds ratios for in-theater Gulf War hospitalizations, August 1, 1990, to July 31, 1991**

Variable	Hospitalized		OR*	95% CI*
	No.	%		
Oil well fire†				
Not under plume‡	6,907	2.7		
Under plume	11,724	2.7	0.79	0.76, 0.81
Khamisiyah hazard area†				
Not in hazard area‡	15,092	2.6		
In the hazard area	3,539	3.6	1.02	0.98, 1.06
Gender				
Male‡	16,332	2.6		
Female	2,299	4.7	1.44	1.37, 1.51
Age (years)				
17–22‡	5,389	2.4		
23–26	4,484	2.8	0.95	0.91, 0.99
27–32	4,103	2.7	0.89	0.85, 0.94
33–65	4,655	3.2	1.00	0.95, 1.05
Prewar hospitalization				
No‡	16,453	2.6		
Yes	2,178	5.2	1.80	1.72, 1.89
Marital status				
Single‡	7,272	2.2		
Married	11,359	3.2	1.46	1.41, 1.51
Military pay grade				
Enlisted‡	17,174	2.8		
Warrant officer	261	2.9	0.84	0.74, 0.95
Commissioned officer	1,196	1.8	0.56	0.52, 0.59
Race/ethnicity				
White‡	13,040	2.8		
Black	4,755	3.0	0.88	0.85, 0.91
Other	836	1.3	0.45	0.42, 0.49
Service component				
Active duty‡	14,676	2.5		
Reservists	3,955	3.9	1.54	1.48, 1.61

Table continues

**TABLE 5. Continued**

Variable	Hospitalized		OR	95% CI
	No.	%		
Branch of service				
Army‡	12,685	3.7		
Navy and Coast Guard	1,362	0.9	0.24	0.23, 0.26
Marines	2,197	2.1	0.60	0.57, 0.63
Air Force	2,387	2.9	0.76	0.72, 0.79
Time period in theater				
August–October, 1990				
Not in theater‡	7,693	2.2		
In theater	10,938	3.4	1.64	1.58, 1.71
November 1990–January 1991				
Not in theater‡	2,851	1.7		
In theater	15,780	3.1	1.48	1.41, 1.56
February–April, 1991				
Not in theater‡	2,501	2.8		
In theater	16,130	2.7	0.75	0.71, 0.79
May–July, 1991				
Not in theater‡	12,037	2.9		
In theater	6,594	2.5	0.93	0.90, 0.96
Occupational category				
Infantry, gun crews, and seamanship specialists‡	3,730	2.2		
Electronic equipment repairers	822	1.6	0.81	0.75, 0.88
Communications/intelligence	1,517	2.3	0.91	0.86, 0.97
Health-care specialists	1,894	4.0	1.56	1.46, 1.65
Other technical support	471	3.3	1.15	1.04, 1.27
Functional support specialists	2,493	3.0	1.10	1.04, 1.16
Electrical/mechanical repair	3,290	2.5	1.09	1.04, 1.14
Craft workers	732	2.9	1.37	1.26, 1.49
Service and supply handlers	3,469	4.0	1.44	1.37, 1.52
Nonoccupational	213	2.6	1.27	1.10, 1.46

\* OR, adjusted odds ratio from multivariable logistic regression; CI, confidence interval.

† Data sources are recorded in detail in previous publications (21–23).

‡ Referent category.

veteran's total number of days in theater was collinear with the period in-theater variables; it was therefore excluded from further modeling. After withdrawing this variable, the regression diagnostics indicated that no two variables were excessively correlated.

The multivariable logistic regression model revealed significant associations between demographic variables and in-theater hospitalization after adjusting for all other variables in the model (table 5). Women had 1.44 times the odds of hospitalization compared with men (odds ratio (OR) = 1.44, 95 percent confidence interval (CI): 1.37, 1.51). Married personnel were at increased odds of in-theater hospitalization compared with nonmarried personnel (OR = 1.46, 95 percent CI: 1.41, 1.51), and Reservists or National

Guard personnel were at increased odds of hospitalization when compared with active duty personnel (OR = 1.55, 95 percent CI: 1.48, 1.62). Those personnel with prewar hospitalizations had increased odds of in-theater hospitalization when compared with those without an inpatient record from the previous year (OR = 1.80, 95 percent CI: 1.72, 1.89). Personnel aged 23–26 years (OR = 0.95, 95 percent CI: 0.91, 0.99) and those aged 27–32 years (OR = 0.89, 95 percent CI: 0.85, 0.94) had decreased odds of in-theater hospitalization when compared with personnel 17–22 years of age. When compared with the Army, all other branches of service displayed lower odds of hospitalization, as did officers when compared with enlisted members (commissioned: OR =

**TABLE 6. Frequencies for the five most common in-theater hospitalization diagnoses for US Gulf War veterans by occupational category, August 1, 1990, to July 31, 1991**

ICD-9-CM* category	Diagnosis	Frequency of diagnoses (no.)	% of category's diagnoses
Infantry, gun crews, and seamanship specialists ( <i>n</i> = 6,155)			
Code 724	Other and unspecified disorders of back	215	3.5
Code 558	Other noninfectious gastroenteritis and colitis	209	3.4
Code 959	Injury, other and unspecified	200	3.3
Code 844	Sprains and strains of knee and leg	150	2.4
Code 836	Dislocation of knee	138	2.2
Health-care specialists ( <i>n</i> = 2,891)			
Code 558	Other noninfectious gastroenteritis and colitis	196	6.8
Code 493	Asthma	87	3.0
Code 789	Other symptoms involving abdomen and pelvis	85	2.9
Code 724	Other and unspecified disorders of back	80	2.8
Code 780	General symptoms (e.g., sleep disturbance, drowsiness)	72	2.5
Functional support specialists ( <i>n</i> = 3,839)			
Code 558	Other noninfectious gastroenteritis and colitis	208	5.4
Code 724	Other and unspecified disorders of back	142	3.7
Code 493	Asthma	114	3.0
Code 786	Symptoms involving respiratory system and other chest symptoms	114	3.0
Code 780	General symptoms (e.g., sleep disturbance, drowsiness)	97	2.5
Craft workers ( <i>n</i> = 1,135)			
Code 724	Other and unspecified disorders of back	47	4.1
Code 558	Other noninfectious gastroenteritis and colitis	37	3.3
Code 719	Other and unspecified disorders of joint	30	2.6
Code 836	Dislocation of knee	27	2.4
Code 682	Other cellulitis and abscess	26	2.3
Service and supply handlers ( <i>n</i> = 5,422)			
Code 558	Other noninfectious gastroenteritis and colitis	281	5.2
Code 724	Other and unspecified disorders of back	232	4.3
Code 786	Symptoms involving respiratory system and other chest symptoms	159	2.9
Code 780	General symptoms (e.g., sleep disturbance, drowsiness)	124	2.3
Code 959	Injury, other and unspecified	124	2.3

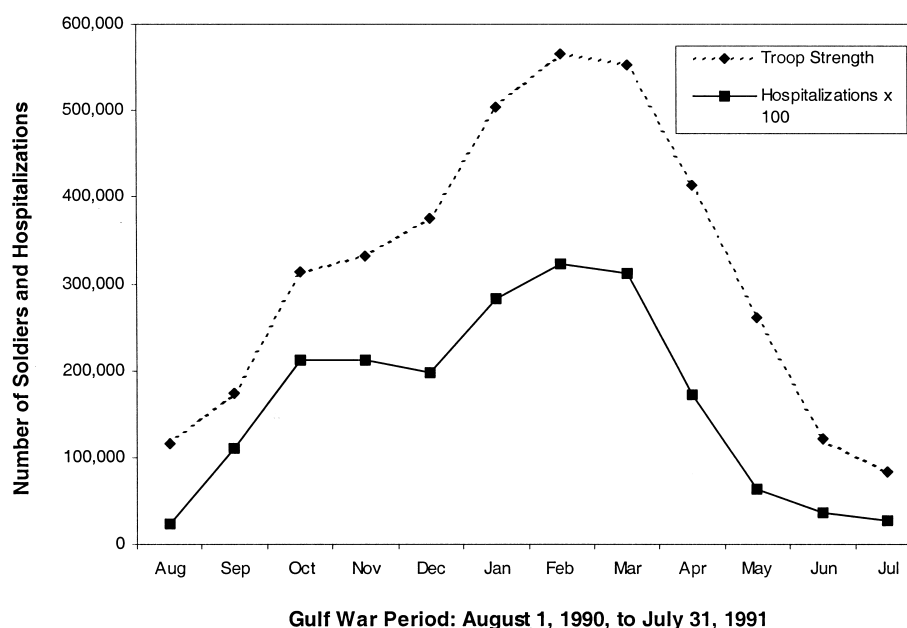
\* ICD-9-CM, *International Classification of Diseases*, Ninth Revision, Clinical Modification, using three-digit codes.

0.56, 95 percent CI: 0.52, 0.59; warrant officer: OR = 0.84, 95 percent CI: 0.74, 0.95).

Investigation of wartime exposures in the multivariable model after adjustment for all other variables did not reveal a possible cause of morbidity severe enough to warrant hospitalization during the war. Those personnel who were in the Gulf region from August to October of 1990 suffered increased odds of hospitalization in comparison with those who were not present (OR = 1.64, 95 percent CI: 1.58, 1.71), while those who were in theater from February to April of 1991 had the lowest odds of hospitalization (OR = 0.75, 95 percent CI: 0.71, 0.79). Possible exposure to the Khamisiyah hazard area was not a significant determinant of in-theater

hospitalization. Those who were exposed to the Kuwaiti oil well fire smoke had odds of in-theater hospitalization of 0.79 when compared with those not exposed (95 percent CI: 0.76, 0.81).

When compared with infantry, gun crew, and seaman (combat) specialists, health-care workers had 1.56 times the odds of in-theater hospitalization (95 percent CI: 1.46, 1.65), service and supply handlers had 1.44 times the odds (95 percent CI: 1.37, 1.52), craft workers had 1.37 times the odds (95 percent CI: 1.26, 1.49), and functional support had 1.10 times the odds of in-theater hospitalization (95 percent CI: 1.04, 1.16) (table 5). From these five categories, unspecified disorders of the back (ICD-9-CM code 724) and noninfec-



**FIGURE 1.** Distribution of troop strength and number of in-theater hospitalizations during the Gulf War period, August 1, 1990, to July 31, 1991.

tious gastroenteritis and colitis (ICD-9-CM code 558) were the most common. General symptoms, such as sleep disturbance or drowsiness (ICD-9-CM code 780), were in the top five most common three-digit diagnoses for health-care workers, functional support personnel, and service and supply handlers (table 6).

## DISCUSSION

During the 1991 Gulf War, almost 697,000 US military personnel were deployed to the Gulf War theater for what was one of the shortest full-scale conflicts in US history. Prior to the war, there was concern that the coalition forces assembled to confront the Iraqi occupying force would see heavy casualties as they met tough resistance from a seasoned Iraqi military. This did not happen, and the US military experienced morbidity and mortality rates that were lower than in previous conflicts (3).

As part of our continuing efforts to assess plausible relations among potential Gulf War exposures and health outcomes, we examined 30,740 diagnoses among 18,631 US personnel who were hospitalized during the Gulf War. The number of hospitalizations was proportional to the number of service members in the region during the 1-year period of operations (figure 1). Many of the diagnoses were of general symptoms, such as sleep disturbance or drowsiness, which may be reflective of a war setting and harsh environmental conditions. Furthermore, the categories of "injury and poisoning" and "musculoskeletal system disorders" comprised nearly 40 percent of the diagnoses (table 2). The five most common diagnoses in these categories reflected dislocations, sprains, and strains of knees, ankles, joints, and backs. Digestive system diseases made up the third most

frequently diagnosed category (12.6 percent). Over 40 percent of the diagnoses in this category were from other noninfectious gastroenteritis and colitis diagnoses. This condition was also identified as the most frequently diagnosed (5.1 percent) among the top 10 any-cause diagnoses (table 3). The top 10 most frequent diagnoses among US allies were similar to those among US personnel except for diagnoses consisting of open wounds or complications of medical care, likely indicative of needed emergency services (table 4).

Our findings of increased adjusted odds of in-theater hospitalization among enlisted, female, White, Reservist, Army, health-care specialist, and supply handler personnel are consistent with reports of postwar hospitalizations (table 5) (13, 14). It is interesting to note, and consistent with past research of postwar hospitalizations, that those possibly exposed to Kuwaiti oil well fire smoke were not at increased odds of acute symptoms severe enough to warrant hospitalization during the war (21). Also consistent with past research of postwar hospitalizations, there was no significant association found between possible chemical warfare agent exposure in the hazard areas created by the destruction of the Khamisiyah munitions depot and in-theater hospitalization (22, 23). Additionally, investigation using two models restricted to specific times encompassing these two possible exposures separately found no significantly elevated measure of association with hospitalization. These exposures were considered by many to be some of the most significant events of the 1991 Gulf War, resulting in great concern over the possibility of diminished health during the war and after the fighting had ceased (29, 30, 34). However, our initial investigation does not support such concerns. Further investigation of these subpopulations of Gulf War

veterans is under way to help understand whether possible exposure to oil well fire smoke or the destruction of the Khamisiyah munitions depot resulted in specific illnesses or conditions warranting hospitalization during the Gulf War.

We investigated five robust occupational categories that were found to be at increased odds of in-theater hospitalization when compared with combat specialists (table 6). Because of the frequency with which these diagnoses occurred in these analyses, it is not surprising that unspecified disorders of the back and noninfectious gastroenteritis and colitis were identified in the top five diagnoses among each occupational category investigated. However, injuries, including sprains, strains, and dislocations of the knee and other joints, were common to combat and support personnel. Symptoms involving the respiratory system, asthma, and general sleep disturbance or drowsiness were common to health-care specialists, functional support specialists, and service and supply handlers.

This report has a number of limitations that should be noted. First, these data are not a complete assessment of hospitalizations occurring in theater during the Gulf War. For example, some US personnel were treated in host nation hospitals run by Saudi Arabia, and records from these facilities are not available. Additionally, the exact number of admissions to DoD military hospitals in the Kuwaiti theater of operations is uncertain. We report on approximately 22,000 hospitalizations in the Kuwaiti theater of operations that represent approximately 75 percent of the total reported admissions by the Air Force ( $n = 3,494$ ), the Navy ( $n = 6,613$ ), and the Army ( $n = 19,941$ ) (32). Furthermore, this investigation focused on morbidity severe enough to require hospitalization. It is possible that, in a wartime setting, some injuries and illnesses ordinarily resulting in a hospitalization while in garrison or on normal duty may be treated in the field or at outpatient or mobile clinics; therefore, our ability to examine medical treatment, particularly during the combat period, is diminished.

Although extensive efforts were made to accurately model potential exposure to oil well fire smoke and Khamisiyah nerve agents, acquiring precise individual-level exposure data is challenging, and presumed exposures should be viewed with some caution (22, 23). Additionally, we were not able to investigate or control for other exposures that may have had an effect on the outcomes reported here, such as smoking, alcohol use, stress, and jet fuel. Furthermore, the use of logistic regression does not take into account person-time at risk for an event the way survival analytical techniques would. Although we know that personnel came and went during the conflict, there was not enough confidence with theater dates at an individual level to employ a time-to-event type modeling approach.

Despite these limitations, these data offer the first large epidemiologic investigation of morbidity occurring during the 1991 Gulf War. Hospitalization data alone may not represent the entire spectrum of health outcomes. However, these data reflect a more contemporaneous and objective measure of morbidity than later self-reports of symptoms and illnesses might. The use of sophisticated meteorologic and dispersion modeling techniques was integrated with unit tracking to identify those possibly exposed to the potential

low levels of nerve agent in the hazard areas near Khamisiyah and those possibly exposed to Kuwaiti oil well fire smoke. The combination of these exposure data with in-theater hospitalization data presents the first objective assessments of associations between acute morbidity severe enough to warrant hospitalization and potentially hazardous wartime exposures. Prior investigations also were insufficient at investigating morbidity in Reserve and National Guard populations, because these subpopulations left military service after the war and were no longer visible through the DoD health-care system. In this report, we were able to investigate Reserve and National Guard members in the same context as we were able to investigate active-duty members.

In summary, our analyses demonstrated important independent factors associated with in-theater hospitalization during the 1991 Gulf War. We found that the distribution of diagnoses was consistent with the physical stress and harshness of a combat environment, and that subgroups consisting of combat and support personnel were frequently diagnosed with similar conditions. There were no unusual patterns in the number of hospitalizations when compared with troop strength. It should be reassuring to US personnel that these data suggest that US military personnel possibly exposed to oil well fire smoke or chemical warfare agents in the Khamisiyah hazard areas were not at increased odds of in-theater morbidity when compared with nonexposed US military personnel. The lessons of the Gulf War have encouraged movement toward force health protection within the DoD (35–37). This movement, along with technologic advancements, will help to standardize reporting of health outcomes on the battlefield, to alleviate concerns of veterans and the public in a much more timely manner, and to guide health-care resources quickly and efficiently to those personnel in need of care.

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